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EXAMINATION OF RETURNED SOLAR-MAX SURFACES FOR IMPACTING ORBITAL DEBRIS AND METEOROIDS. D.J. Kessler, H.A. Zook, A. E. Potter, D.S. McKay (NASA/JSC, Houston, TX 77058), U.S. Clanton (Dept. of Energy, P.O. Box 14100, Las Vegas, NV, 89114), J.L. Warren, L.A. Watts (Northrop, P.O. Box 34416, Houston, TX 77234), R.A. Schultz (Purdue Univ., Dept. of Geosciences, West Lafayette, IN 47907), L.S. Schramm, S.J. Wentworth, and G.A. Robinson (Lockheed, 1830 NASA Rd. 1, Houston, TX 77058).

Previous theoretical studies (1) predicted that in certain regions of earth orbit, the man-made earth orbiting debris environment will soon exceed the interplanetary meteoroid environment for sizes smaller than 1 cm. Recent analyses of impact measurements obtained from Explorer 46 (2), Skylab experiment S-149 (3), The Apollo/Skylab windows (4), and the STS 7 Shuttle window (where a 2mm high-velocity impact crater was found to contain titanium with a trace of aluminum) suggest that a significant orbital debris population already exists in earth orbit (5). However, these experiments had either short exposure times, no conclusive technique to differentiate debris from meteoroids, or an altitude or time of flight where a lesser amount of debris would be expected. The surfaces returned from the repaired Solar Max Mission (SMM) by STS 41-C on April 12, 1984, offered an excellent opportunity to examine both the debris and meteoroid environments.

Solar Max was launched on February 14, 1980, into a near circular orbit at 570 km altitude, and an inclination of 28.5°. By April 10, 1984, the orbit had decayed to 500 km and SMM was captured for repair in the shuttle payload bay, after nearly 50 months of exposure to space. The returned surfaces included about 1.5 sq.met. of thermal insulation material and 1.0 sq. met. of aluminum thermal control louvers. The thermal insulation consisted of 17 layers of alumized kapton or mylar, each separated by a dacron net, and the louvers consisted of 2 layers of heavy aluminum foil separated by about 3 mm. These types of surfaces offer excellent opportunities to obtain chemistry of impacting particles.

To date, approximately 0.7 sq. met. of the thermal insulation and 0.05 sq. met of the aluminum louvers have been mapped by optical microscope for crater diameters larger than 40 microns. Smaller craters were recorded in some cases; however, smaller craters are increasingly difficult to recognize optically. In addition, atomic oxygen has eroded up to 20 microns of the exposed kapton surfaces(6), removing the older and smaller craters. Figure 1 shows the crater size distribution found on 3 different kapton surfaces. Craters larger in diameter than about 100 microns found on the initial 75 micron thick Kapton first sheet on the MEB (Main Electronics Box) blanket are actually holes and constitute perforations through that blanket. Similarly, 70 micron craters form complete holes through the initial 50 micron thick first sheet of thermal blankets #6 and #9. About 160 craters were found to have penetrated these surfaces. Based on very limited calibration data, this is a factor of 2 to 5 above what would be expected from the meteoroid flux alone.

The chemical study of these craters is only in the initial stages. About 250 chemical spectra have been recorded of particles observed in or around impact pits or in the debris pattern found on the second layer beneath impact holes in the outer layer. Chemistry is obtained via a PGT 4000 Energy Dispersive Spectrometer on a JEOL JSC-35CF Scanning Electron Microscope (SEM).

The following populations have been found to date in impact sites on these blankets:

Meteoritic material-characterized mainly by particles or droplets composed primarily of Si, Mg, Fe, Ca, and Al, or less often, iron-nickel sulphides. A more detailed analysis of the meteoritic component is given in (7).

Paint particles - Characterized by titanium and zinc, whose oxides form pigments for white thermal paints. The chemistry of these particles also includes potassium, silicon, aluminum, and chlorine. Potassium silicate is used as a "binder" to cement the pigment grains together. Aluminum is apparently used for pigmentation. The source of the chlorine in these particles is not yet understood. It is not yet clear whether the paint particles have impacted at high or at low velocity. This may become understood when the aluminum louvers are examined in detail.

Aluminum droplets-For these craters, only aluminum droplets are observed in the ejecta on the second sheet. The ejecta patterns observed on the second sheet are well spread out and are composed of finely divided particles or droplets. These impacts are most likely caused by man-made space debris.

Waste particles-This single impact went through three layers of the blanket. Chemistry was Na, K, Cl, P and minor amounts of sulphur. Sodium and potassium chlorides, sulphur, and minor amounts of phosphates are consistent with urine residue. This particle was almost certainly an ice particle from the Shuttle waste management system.

The Solar Max thermal blankets (and louvers) represent a very valuable resource of information about the near-Earth impacting particle population. The chemistry found within most of the craters is consistent with an origin other than meteoroids. Because of the many different sources of particles, some time is required before the chemically different populations can be quantitatively separated into clearly recognized origins.

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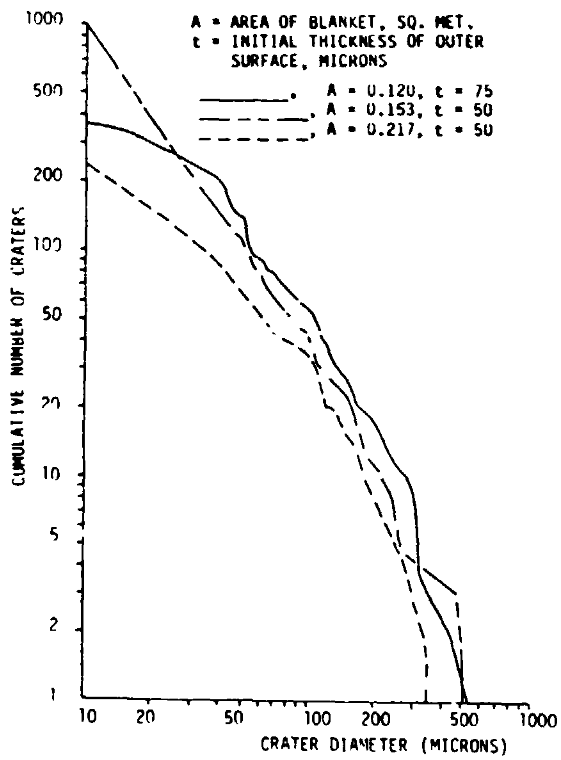

FIGURE 1. COMPOSITE OF CUMULATIVE SIZE PLOTS FOR SOLAR MAX MEB, 9, and 6 BLANKETS